The Growth Response Of Northern Red Oak Following Partial Cutting

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The Georgia-Pacific—West Virginia University Experimental Forest

The 3,000-acre Georgia-Pacific — West Virginia University Experimental Forest was established in 1951 on lands then owned by the Island Creek Coal Company. Until 1965 this research forest was known as the "Island Creek Experimental Forest." At that time the surface ownership was acquired by the Georgia Pacific Corporation, and a new cooperative research agreement was completed between the West Virginia University Board of Governors and the present owners. Since 1951 the timber management practices and research activities have been supervised by the faculty of the West Virginia University Division of Forestry.

This research forest is located in Mingo County in the extreme southwestern part of West Virginia, the heart of the bituminous coal fields. These lands are presently considered of value primarily for their extensive coal deposits. The purposes in establishing this forest were to demonstrate that Appalachian coal lands can also yield substantial returns as a continuous source of high-quality hardwoods, and to determine the best methods of forest production and utilization for the rugged terrain typical of this section of the State.

Topography divides the research forest into five natural units. These vary in size from 250 to 750 acres. Each unit, in turn, is subdivided into compartments of from 25 to 140 acres. Between 1953 and 1960 the mature timber on each compartment was harvested using seed-tree cuttings or shelterwood cuttings on one-half of the compartment and single-tree selection cuttings with 10- or 20-year cutting cycles on the remaining area. Since most of the compartments extend from creek bottom to ridge line, replicated areas exist which are ideal for comparing the effectiveness of these regeneration methods on the various slope positions and aspects, and studying the effects of these cuttings on the growth rate and quality of the residual trees.

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Introduction

MANY YOUNG OAK stands develop from regeneration already present on the forest floor at the time the mature stand is cut (Carvell and Tryon 1961). Stands with adequate amounts of thrifty oak reproduction are often clearcut to release the oak understory, which acts as the nucleus of the new stand (Carvell 1967). Some oak stands, however, have no understory at the time of cutting, or are deficient in desirable species. If oak is to be reestablished on these sites, partial cuttings, usually single-tree selection or shelterwood cuts, are required.

On the Georgia-Pacific — West Virginia University Experimental Forest many northern red oaks (*Quercus rubra* L.) were left as a seed source on the shelterwood and selection compartments cut between 1953 and 1960. In the summer of 1967 sixty-six of these red oaks were studied to determine their growth pattern before and after cutting, and the number of epicormic branches that had developed. It was hoped that through this study those tree characteristics or environmental conditions could be identified that result in favorable growth response and the least epicormic branching when northern red oaks are isolated by cutting.

Review of Literature

Most studies of hardwood growth response have been made in small-pole-stage stands. Guise (1925) observed that mixed hardwoods, including northern red oak, responded favorably to thinning when one-half of the basal area was removed, but showed little response when only one-third of the basal area was cut.

Holcomb and Bickford (1952) studied the growth of yellow-poplar (*Liriodendron tulipifera* L.) and associated species, including red oak, in unthinned West Virginia stands. They found that red oak diameter growth was much lower than that of yellow-poplar. The most vigorous red oaks were increasing at the rate of 2.30 inches in 10 years.

Smith (1965) found that northern red oak when exposed on one face produced more epicormic branches than black cherry (*Prunus serotina* Ehrh.), and that yellow-poplar produced the least epicormic branching.

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Following thinning in pole-stage yellow-poplar. Wahlenberg (1950) observed that the number of epicormics increased with the degree of release and that most sprouts appeared on the open side of the bole. The most abundant epicormic branching was on lower-crown-class trees. Some genetic variation was evident between individual trees, with the light sprouters outnumbering the heavy sprouters three to one.

Ward (1966), in studies of epicormic branching on white oak (*Quercus alba* L.) and black oak (*Quercus velutina* Lam.) after a thinning in a 55-year-old stand, found that epicormic production was more closely related to the number and distribution of pretreatment live branches than to level of stocking of the residual stand or vigor of the sample trees.

Description of Experimental Area

The topography within the experimental forest consists of steep, V-shaped valleys. Twenty-five per cent slopes are common, and occasionally grades as great as 50 per cent are encountered. In 1953, when the first experimental cuttings were made, the second-growth stands were essentially evenaged and approximately forty years old.

From the time of the first logging operations until the West Virginia University Division of Forestry assumed administration of this tract, ground fires burned frequently in the fall and spring. Since 1951 most of the research forest has been free from wildfire. These early fires have caused many trees to develop catface and butt rot.

Cove hardwood types predominate on the lower- and middle-third slopes and are abundant on the north-facing upper third slopes. The major components of these mixtures are yellow-poplar, northern red oak, basswood (*Tilia americana* L.), white ash (*Fraxinus americana* L.), blackgum (*Nyssa sylvatica* Marsh.), sugar maple (*Acer saccharum* Marsh.), and red maple (*Acer rubrum* L.). Oak-hickory mixtures dominate south-facing upper-third slopes and ridges. Here white oak and chestnut oak (*Quercus prinus* L.) predominate, and northern red oak, hickory (*Carya* spp.), and blackgum are associates.

The productivity of the Forest is attested to by the size of the forty-year-old trees removed when the second-growth stands were cut. During this rotation some of the yellow-poplar had attained diameters of 20 inches, and cucumbertree (*Magnolia acuminata* L.) and northern red oak, 16 inches. The tallest trees exceeded 100 feet in height.

Collection of Data

In the summer of 1967 sixty-six northern red oaks were selected from various slope positions and aspects on selection and shelterwood compartments. At the time of release these oaks ranged in d.b.h. from 7.0 to 22.3 inches, and averaged 14.8 inches. During the cuttings which began in 1953 and extended through 1960 the crowns of these trees had been exposed on three or more faces. An equal number of study trees were selected from lower-, middle-, and upper-third slope positions. The number of study trees by aspect and slope position is presented in Appendix Table 1.

In 1968 seventeen red oaks from adjacent uncut stands of the same age, condition and density as the selection and shelterwood compartments prior to cutting were selected for controls to determine their diameter growth pattern from 1948 to 1967.

In studying each northern red oak on the selection and shelterwood compartments, the following measurements or observations were made: present d.b.h., d.b.h. at time of cutting (from increment cores), total height, height to lowest live branch, and number of dead branches in crown. Evaluation of the environmental conditions around each red oak included record of aspect, per cent slope, and slope position. The opening around each red oak was mapped, showing the distance to the crown of the nearest tree of comparable size.

The extent of logging damage to the bole and the degree of soil disturbance around each tree were also recorded. Epicormic branching was rated as none, light, moderate, or heavy. Trees with 10 epicormics or less restricted to the area immediately below the main crown were classified as light, and trees with numerous epicormics extending nearly to the base were classified as heavy. Those falling in between these two classes were rated as moderate.

From the increment cores the annual radial increment for the seven years before cutting and the seven years after cutting was measured.

For the control trees the following measurements were made: present d.b.h., and annual radial growth from 1948 through 1967. Aspect, slope position, and per cent slope were also recorded.

Analysis of Data

Diameter Growth. Plotting of the annual diameter increment for the seven years after each oak was released indicated that the pattern

was a straight-line relationship. Thus, a regression equation was selected of the form:

$$Y = b_0 + b_1X$$

where

Y = diameter increment in inches for a specific year after the oak was released,

X = number of years since cutting.

Initially separate regressions were computed for oaks on lower-, middle-, and upper-third slope positions. Tests showed that the regression coefficients for trees on the lower- and middle-third slopes were not statistically significant, indicating that the red oaks on these slope positions neither increased nor decreased significantly in rate of diameter growth during the seven years following isolation. The regression coefficient for the upper-third slope position was positive and significant at the 1 per cent level, indicating that the diameter growth of red oaks on upper slopes increased slightly following isolation. When the data for the red oaks from all slope positions were pooled, the regression coefficient was not significant (Table 1).

Similar analysis of the diameter growth of the controls indicated that there had been a small but significant decrease in diameter growth from 1948 through 1967. The regression equation for these data are presented in Table 2. A comparison of the diameter growth rate of the released trees and the controls is shown in Figure 1.

To discover whether all northern red oaks, regardless of diameter growth rate at time of release, responded similarly, the correlation between diameter increment in the seven years prior to isolation (X) and the diameter increment in the seven years after isolation (Y) was investigated. This produced the significant equation (1 per cent level):

$$Y = 1.1758 + 0.3346\,X$$

Table 3 shows a tabulation of growth data by vigor classes. The average diameter growth before and after release by slope position and aspect is presented in Appendix Tables 2 and 3, respectively.

Statistical tests failed to show any correlation between diameter growth pattern before and after cutting and aspect or per cent slope. There was also no correlation between the amount of soil disturbance around the oak during logging and changes in diameter growth.

Epicormic Branching. The ratings of the 66 trees for epicormic development are shown in Table 4. Various tests were made between degree of epicormic branching and environmental factors. There was no statistical correlation between the number of epicormics and distance to the nearest tree of comparable size, d.b.h. at time of cutting, aspect, crown length, or slope position.

Table 1. Regression equations showing the annual diameter growth (Y) for a specific year after cutting (X) by slope position

Equation No.	Slope Position	Regression Equation	Significance of Coefficient
1	Lower-third	$0.2439 - 0.0044\ X$	n.s.
2	Middle-third	$0.2814 - 0.0017\ X$	n.s.
3	Upper-third	$0.2373 + 0.0064\ X$	1%
4	All Slope Positions	$0.2505 + 0.0013\ X$	n.s.

Table 2. Regression equations showing the annual diameter growth (Y) for unreleased red oaks for each year after 1947 (x) by slope positions

Equation No.	Slope Position	Regression Equation	Significance of Coefficient
5	Lower-third	$0.1483 - 0.0004\ X$	n.s.
6	Middle-third	$0.2804 - 0.0025\ X$	5%
7	Upper-third	$0.3685 - 0.0048\ X$	1%
8	All Slope Positions	$0.2876 - 0.0031\ X$	1%

Table 3. Comparison of total diameter growth seven years before and seven years after cutting by vigor classes. Only 59 red oaks are included in this tabulation due to incomplete data on seven trees for diameter growth the sixth and seventh years prior to cutting

Vigor class	Range in diameter growth for the 7 years before cutting inches	Average diameter growth for 7 years prior to cutting inches	Average diameter growth for 7 years after cutting inches	Per cent change
Below average	0.30—0.99	0.71	1.29	82.15
Average	1.00—1.69	1.38	1.60	15.78
Above average	1.70—2.49	2.09	1.96	− 6.32
Excellent	2.50—3.38	2.87	2.08	−38.18

Table 4. Ratings of the red oak study trees for epicormic branching 8 to 15 years after release

Epicormic rating	Number of Trees	Per cent of Trees
None	5	7.6
Light	18	27.2
Moderate	13	19.7
Heavy	30	45.5
Total	66	100.0

Discussion

Although growth response is often given as a primary reason for releasing sapling- and small-pole-stage oaks, an examination of the regression equations in Table 1 suggests that larger red oaks do not usually exhibit the growth response reported for younger trees. The regression equation for the control trees indicates that there was a small but significant decrease in diameter growth annually between 1948 and 1967 (Table 2). Actually, such a decrease is to be expected even when the total amount of wood fiber produced each year is constant, since the new wood is being distributed over an increasingly larger girth.

If we assume that a slight decrease in diameter growth is to be expected in oaks of this diameter with successive years, it appears that there was actually an increase in wood production for the released red oaks following isolation. Equations 1 and 2 indicate that released oaks on lower- and middle-third slope positions showed no significant change in annual diameter growth after isolation, suggesting expanding crowns and increased annual production of wood fiber at breast height over unreleased trees. Red oaks on upper-third slopes actually showed an increase in diameter growth (Equation 3). These changes in annual

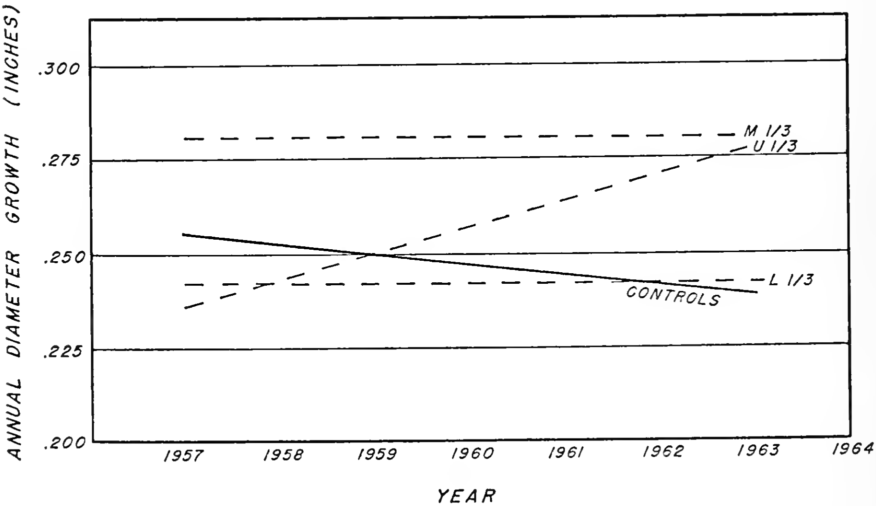

FIGURE 1. *A comparison of the diameter growth rate of the controls and the released red oaks during the period from 1957 through 1963. Although the middle- and lower-third slope oaks did not show an increase in annual diameter growth, they did not decline during this period, suggesting an annual increase in wood fiber production.*

diameter growth after release are shown in Figure 1. The lines for the released trees show what would be the pattern for red oaks released in 1957, mid-way through the harvest period on this Forest.

This study indicates that northern red oaks of above average and excellent vigor actually declined slightly in diameter growth as a result of release (Table 3), and that average and below average vigor oaks increased in diameter growth. A similar growth pattern was found in previous studies of yellow-poplar on this tract (Carvell 1968). Actually red oak maintained a better diameter growth after cutting than did yellow-poplar. Poplar diameter growth prior to release was 50 per cent greater than that of northern red oak, yet seven years after release the poplar was growing 20 per cent slower than the released red oaks.

The number of dead branches in the crowns of isolated red oaks was smaller than for isolated yellow-poplars (Carvell 1968), and there was no evidence that isolated red oaks would become stagheaded and start to die back from the top, a characteristic often observed in yellow-poplar seed trees.

Sixty-five per cent of the isolated red oaks exhibited moderate or heavy epicormic branching. This tendency appeared to be genetically controlled, since some heavily-released red oaks showed little or no epicormic production.

This study suggests that when choosing large-pole-stage and young-timber-stage red oaks for seed production in selection and shelterwood cuttings, trees of above average vigor should be preferred. Although no spectacular increase in diameter growth can be anticipated, diameter growth will remain the same or decline only slightly. Vigorous trees should be far more capable of immediate heavy acorn production than are oaks of poor and average vigor. Epicormic production can be reduced by leaving only oaks which show no tendency towards epicormic development prior to release (Ward 1966). If these red oaks are to be left as a seed source for a decade or less, the superficial pin knots produced by these branches will be of no significance, since the lower grade, knotty wood will be removed in the slabs when the log is made into a cant.

Summary

In 1967 sixty-six northern red oaks were examined from various slope positions and aspects on compartments that had received selection or shelterwood cuttings during the 1950's. These oaks had been exposed on three or more faces during the regeneration cuttings. Seventeen red oaks from adjacent uncut stands were used for controls.

During the period from 1948 through 1967 the unreleased controls exhibited a small but significant decrease in annual diameter growth. This decrease was attributed to the new wood being distributed over an increasingly larger girth.

Released northern red oaks on lower- and middle-third slopes showed no change in diameter growth rate during the seven years after cutting. Since their diameter growth rate did not decline, as that of the controls during this period, it appears that there was a slight increase in annual wood production after release. Released red oaks on upper-third slopes showed a slight increase in annual diameter growth during this period.

The number of dead branches in the crowns of released red oaks was smaller than for isolated yellow-poplars, and there was no evidence that isolated red oaks would become stagheaded as a result of exposure.

Sixty-five per cent of the isolated red oaks exhibited moderate or heavy epicormic branching. This tendency appeared to be genetically controlled, since some heavily-released red oaks showed little or no epicormic production.

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APPENDIX

Table 1. Distribution of released northern red oak study trees by aspect and slope position

Slope Position	N	NE	E	Aspect SE	S	SW	W	NW
Lower 1/3	0	7	3	6	0	6	1	0
Middle 1/3	1	14	0	5	0	2	0	0
Upper 1/3	4	6	4	7	0	0	0	0
Total	5	27	7	18	0	8	1	0

Table 2. Average diameter growth for the seven-year period before and seven-year period after release by slope position

	Slope Position		
	Lower 1/3	Middle 1/3	Upper 1/3
Before release	1.530	2.024	1.736
After release	1.592	1.974	1.756

Table 3. Average diameter growth by aspect for the seven-year period before and the seven-year period after release

	Aspect							
	N	NE	E	SE	S	SW	W	NW
Before release	1.848	1.820	1.610	1.722	——	1.512	2.260	——
After release	1.952	1.702	1.890	1.742	——	1.765	2.480	——